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WEST AFRICAN COCOA RESEARCH INSTITUTE

QUARTERLY PROGRESS REPORT

No. 50

TAFO, GHANA

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WEST AFRICAN COCOA RESEARCH INSTITUTE

TAFO, GHANA

FIFTIETH QUARTERLY REPORT

APRIL-JUNE, 1958

Any results recorded in this report should not be accepted as conclusive inasmuch as the report contains interim information only. More complete results are published in W.A.C.R.I. Technical Bulletins and elsewhere.

SENIOR STAFF

Director	J. Lamb (on leave)
Deputy Director	C.G. Johnson (returned from leave 10th April)
Scientific Assistant to Director	G.A. Jones
Secretary	H.L. Pugh
Accountant	H.J.S. Mill (arrived 4th June)
Assistant Accountant	J.N.A. Hyde
Office Assistant/Librarian	June Nicholas (temporary: resigned 30th June)

TAFO STATION

Division of Entomology	P.F. Entwistle
Division of Pathology	J.W. Blencowe
	A.L. Wharton (on leave)
	A.A.F. Brunt
	A. Attafuah
Division of Botany	D.R. Glendinning (on leave)
	R.G. Hurd (on leave 23rd May)
Division of Chemistry	R.H. Kenten
	R.K. Cunningham (on leave 21st May)
Division of Agronomy	R.W. Smith
Statistician	C. de Jonge
Laboratory Technicians (electronics)	A.J.H. Arnold
(spectrography)	J.C. Burridge
Plantation Manager	H.W.S. Allison
Maintenance Engineer	A. Maddison
Works Superintendent	E.K. Berko
Guide-Demonstrator	F.E. Decker
Station Manager	S.E. Ntim-Kwafo
Medical Officer	P.K.K. Knudsen (arrived 25th April)

IBADAN SUB-STATION

Deputy Director (Nigeria)	T.W. Tinsley
Entomologists	R.G. Donald
	C.K.H. Martini
Pathologists	J.M. Thresh
	D. Kay
Agronomist	J.F. Longworth (transferred from Tafo 4th April)

STAFF MATTERS

Dr. Johnson returned to Tafo on the 10th April and assumed duties as Acting Director in the absence on leave of Mr. Lamb.

Mr. H.J.S. Mill, previously Accountant at the West African Institute for Oil Palm Research, joined the staff of the Institute in June. Mr. Mill will take charge of the Institute's accounts, and will supervise the reorganisation of the accounting system to conform to normal commercial practice. Mr. J.F. Longworth, Agronomist, was transferred from Tafo to the Ibadan Sub-Station in April. The Chemist of the West African Fungicides Research Unit, Mr. P.O. Park, also arrived at Ibadan in April. Mr. Park and Mr. Hislop spent a few days at Tafo in May. Dr. P.K.K. Knudsen arrived at Tafo on 25th April to take up his appointment as Medical Officer.

VISITORS

Sir Gilbert Laithwaite, U.K. Permanent Under-Secretary of State for Commonwealth Relations spent a day at Tafo during April. The Station was also visited by a number of delegates to the F.A.O. conference held in Accra in May, including the Director-General of F.A.O., Dr. B.R. Sen. Other visitors have included Mr. T. Webb of the U.N. Information Department; Professor Siberis, Agricultural Research Adviser of the I.C.A.; Mr. W.H. Rogers of the Borneo Cocoa Estate, Ltd.; Mr. Fryett of Shell Co.; Mr. Movshon, Superintendent of U.N. External Broadcasting; Mr. R.F.A. Murfitt, Agricultural Officer, Sierra Leone; Mr. Hagrianer of CIBA, Ltd.; Mr. J. Rawnsley, Entomologist of the Cocoa Marketing Board; and a party from the U.S.A. State Department.

Chief Z.A. Opaleye, the Parliamentary Secretary, Ministry of Agriculture and Natural Resources, Western Region, Nigeria, paid a visit to the Sub-Station in May.

MANAGEMENT AND MAINTENANCE

Work has continued on the new Fermenting and Drying Shed, and good progress has been made with the Spectrographic Laboratory.

At the Ibadan Sub-Station the construction of six new insectaries has been started.

CROP DELIVERY

The minor crop started about the middle of May, somewhat later than last year. The number of pods harvested during the quarter is given below:

Month	Old Station	Square Mile	Total
April	-	375	375
May	2,157	7,652	9,809
June	18,761	23,701	42,462
Total	20,918	31,728	52,646

SWOLLEN SHOOT DISEASE

Losses during the quarter from the Uniformity Trial Areas, Old Station, due to swollen shoot disease and other causes are given below:

Month	Trees destroyed		Total	Infected seedlings removed
	Swollen Shoot	Undiagnosed		
April	142	4	146	67
May	47	8	55	75
June	36	-	36	69
Total	225	12	237	211

The numbers of infected and contact trees removed on the Institute land have remained some 10% lower than the monthly average before August, 1957.

A total of 753 infected trees were removed from the Square Mile and Old Station during the quarter.

UPPER AMAZON SEED

During the quarter 500 F3 pods were sent to Eastern Region, Nigeria and 3,745 pods were supplied to the Department of Agriculture, Ghana.

METEOROLOGY

Month	1958		20-year mean	
	Rainfall (in.)	Wet days	Rainfall (in.)	Wet days
April	4.82	9	6.12	11.3
May	17.36	15	7.08	14.0
June	11.16	20	8.48	18.8
Total	33.34	44	21.68	44.1

T A F O S T A T I O N

PATHOLOGY DIVISION

VIRUS RESEARCH

The discovery of a virus disease of cacao in Sierra Leone

At the request of the Department of Agriculture of Sierra Leone, Mr. A. Attafuah visited the Protectorate to make a search for cacao possibly infected with virus. He visited some 90 farms in the main cocoa-producing areas, and discovered one outbreak of virus disease, with about 100 infected trees. This is the first record of a cacao virus in Sierra Leone. The virus has been transmitted to healthy cacao both by grafting and by the mealybug Pseudococcus njalensis Laing. The virus was relatively mild in its effect on young seedlings, but nothing is yet known of its possible relationships with other virus diseases of cacao in West Africa.

The virus was discovered on a cocoa farm in the Gandahun district on the banks of the Moa River between Kenema and Kailahun. The farm was at a point where a footpath from the river leads to the inaccessible forest districts of western Liberia. It is possible that infected material may have been carried into Sierra Leone along this route. The possibility that infected trees may have been swept down the Moa River in flood-time and deposited on the bank at Gandahun was investigated, but no infected trees were found on farms higher up the river towards Kailahun and French Guinea.

There is a large Ceiba pentandra Gaertn. growing in the centre of the outbreak. It would be most interesting to discover whether this is virus-infected. It is hoped to fell it soon and to strike cuttings for further studies.

Only about 1% of the cacao in the country was inspected during this visit and it is therefore unlikely that this will be the only outbreak discovered in the Protectorate when a more extensive survey is made.

Subsequently, Dr. J.W. Blencowe visited Sierra Leone at the invitation of the Ministry of Agriculture to advise on control measures. Because of the small area at present affected, cutting-out of all infected trees and of symptom-free cacao within 30 yards of the perimeter of the outbreak was recommended. In addition all forest trees known to be susceptible to cacao viruses that are growing within the outbreak should be felled. The chances of eradicating the disease in this area are relatively good. An Agricultural Officer from Sierra Leone has since visited W.A.C.R.I. and the Ghana Department of Agriculture to study the organization

of swollen shoot control.

Resistance and Tolerance

The results of a series of tests of clonal cuttings from F_1 T17/(Iquitos) seedling trees are now complete. The cuttings were more difficult to infect using mealybug vectors than West African Amelonado (WAA). For example, when 50 viruliferous mealybugs were fed on each of 250 fan cuttings taken from 50 different T17 Amazon parents, 119 of them became infected with the Kpeve virus isolate. At the same time, 19 out of 20 comparable cuttings of WAA were infected using comparable batches of infective mealybugs.

The cuttings were more tolerant to infection with the Kpeve virus than to the unrelated severe New Juaben virus. Tolerance to Kpeve was not correlated with tolerance to New Juaben. Parents of plants which were "most tolerant" are being crossed by hand-pollination and the progeny will be compared with those from crosses of "least tolerant" parents. The first pods prepared for this new series of experiments are nearing maturity.

Experiments designed to measure the resistance of Amazon seedlings to infection with swollen shoot virus when bombarded with viruliferous mealybugs while in the bean stage are continuing.

When 3 viruliferous mealybugs were fed on each of 380 dissected beans of WAA, 63% of them became infected with the severe New Juaben isolate, but only 43% of a similar batch of beans of the Amazon T17/1157 became infected. In a similar test with the Kpeve isolate, using 6 infective mealybugs per bean, 32% of the WAA and 26% of the T17/1157 became infected.

Another series of experiments with the New Juaben isolate demonstrated this difference in susceptibility to infection in another way; when batches of dissected beans of WAA and of T17/1853 were bombarded with varying numbers of viruliferous mealybugs, it needed five infective mealybugs per bean to infect 50% of the WAA, but it required nine mealybugs per bean to attain the same rate of infection with the T17/1853.

Insect transmission experiments

Repeated attempts to transmit the Mampong and Bisa isolates with the mealybug Ferrisiana virgata have been unsuccessful. This result differs from that reported by Posnette (Ann.appl.Biol., 37, 378, 1950).

STUDIES ON BLACK-POD DISEASE

The field experiments on the control of black-pod disease in random-planted West African Amelonado cacao are progressing satisfactorily, but it is too early for any effects to be noted.

ENTOMOLOGY DIVISION

CAPSID STUDIES

Joint W.A.C.R.I. and Department of Agriculture capsid control trials

These trials were to test the effectiveness of gamma-BHC, endrin, aldrin, dieldrin and malathion. Gamma-BHC, aldrin and malathion were compared on small plots of 3-4 acres, each treatment (including untreated controls) being replicated five times, while endrin, aldrin and dieldrin were compared on large plots of approximately 100 acres, unreplicated and without untreated controls. The experimental procedure has already been described (see Quarterly Report No. 46).

On both the small- and the large-scale plots the initial treatments were at 4 oz. toxicant in 5 gallons of water per acre applied, with a mistblower, twice with a one month interval in June-July, 1957. All plots were given a second treatment in November-December, 1957.

In the small-scale trial however malathion was abandoned, and the plots were reallocated to gamma-BHC, aldrin and control with 4 oz. toxicant in 5 gallons of water per acre, again twice at a one month interval. In the large-scale trial dieldrin was abandoned, and gamma-BHC substituted; these plots also were re-treated in November-December, applying 1 oz. toxicant in 5 gallons of water per acre twice at a month's interval.

Damage recorded in the small-scale units 56 days after each treatment is shown in Table I. Heavy damage was found in the untreated control plots.

TABLE I

Small-scale capsid control trial

Insecticide applied	56 days after first treatment			56 days after second treatment		
	Total trees	Trees with foliage damage	Trees with pod damage	Total trees	Trees with foliage damage	Trees with pod damage
Gamma-BHC	6854	29	Nil	9098	79	Negligible
Aldrin	8714	106	30	11277	168	Negligible
Malathion	9955	260	708	-	-	-

In the large-scale units two months after the first treatment damage in the endrin and aldrin plots was tolerable, with a difference in favour of endrin. The dieldrin plot showed more damage than was tolerable, and, as already mentioned, this treatment was abandoned in favour of gamma-BHC. Fifty-six days after the second treatment pod damage was negligible in the treated plots. In the endrin plots 19 trees had damaged foliage, out of 4,408 trees, while in the BHC plots there were 58 foliage-damaged trees out of a total of 4,855 and in the aldrin plots 446 damaged trees out of 6,666.

In addition to the series of trials begun last year and described above, a new series has been set up to compare the relative effectiveness of three insecticides applied at rates roughly proportionate to their cost.

In the previous trials endrin gave promising results when applied at the rate of 1 oz. per acre (with an initial double treatment at twice this rate) and it has been agreed that a lower dosage should be tested. The new series of trials have been sited in the Wenchi district and consist of the following treatments:-

1. ½ oz. Endrin
2. 1 oz. Gamma-BHC
3. 2 oz. Aldrin.

The above three will receive their initial double application (July/August) at twice the rate quoted but thereafter treatment will be at the single rate. In addition a fourth treatment has been included in which gamma-BHC is being applied at 1 oz. per acre but with a single rate dosage throughout the

experiment. Each of these four insecticidal treatments will be replicated five times and there are also five replicates of an untreated control.

The plots have been selected upon criteria of uniformity of capsid damage, tree age and to some extent tree density. Each is 3-4 acres in area and has an additional acre situated on its southern aspect acting as an 'adjacent control plot'.

Procedure in damage estimation and canopy regeneration assessment will be as in the earlier series of trials.

MEALYBUG STUDIES

Square Mile. This trial, which ended on the 9th May, illustrated the inadequacy of one application of dieldrin emulsion, to this relatively small area of 40 acres, in effecting an acceptable reduction in vector populations through ant control. There was a good degree of ant control of short duration, but numbers soon increased and were sufficiently organised to support a mealybug population of swiftly increasing numbers.

At the eighth fortnight after dieldrin application populations of adult mealybugs had fallen to 3.0 per cent of their initial pre-treatment count and less than twelve months after spraying had exceeded control plot figures.

Changes in numbers of trees infested followed a similar pattern to population fluctuations. Prior to spraying 75.0 per cent of trees in the treated area had mealybugs, the figure falling to 20.0 per cent in the eighth fortnight after dieldrin treatment and by the 12th fortnight rising again to pre-treatment levels and subsequently above these.

Ant/Mealybug Control Trial - Series II. In June a new trial was laid down in WACRI Square Mile and pre-treatment counts of ants and mealybugs begun.

The addition of coumarone resin to dieldrin is known to prolong its residual effect considerably and the object of the experiment is to compare such a dieldrin/coumarone formulation with straight dieldrin emulsion.

Insecticide application will be at the rate of 1 lb. of toxicant in 20 gallons of water applied over each acre to the trunks of all trees, the second application being made as results indicate. Coumarone resin will be added at the rate of 10 per cent by weight of the actual toxicant, a proportion given as an optimum by the manufacturers.

Three replications of each of the two insecticidal treatments and three of a control treatment are planned, making a total

of nine plots. Each plot is of 10 acres, three to five acres being cacao, the remainder bush. Two transects, along which all trees of any size have been labelled for ant counts, have been struck diagonally through each plot and approximately 200 trees will be examined for ants in each replicate.

The areas containing cacao have been staked out into 50 foot square sub-plots where in each fortnight trees will be felled for mealybug population estimates in a random selection of these. To introduce a measure of uniformity into the trees sampled only those with a girth of eight inches or more, as measured at eighteen inches above ground level, are being felled.

Records of swollen shoot virus incidence are being taken and all visibly infected trees removed. In accordance with established Station practice in experimental plots no contact trees are being felled.

The initial dieldrin application is due at the end of July, 1958 and the question of further applications will depend upon the duration of control obtained in this initial treatment.

Joint W.A.C.R.I. and Department of Agriculture trials on mealybug control

Oyoko. During the quarter mealybug populations in the treated area continued on the upward trend mentioned in the previous Quarterly Progress Report No. 49, whilst those in the control area were beginning to recover from the seasonal decline exhibited in the early months of the year.

The first application of a second double treatment with dieldrin began, approximately 14 months after the first, in June but differed slightly from the previous applications in that 1 lb. of toxicant was applied in only 20 gallons of water to each acre. The reason for this is that, as routine capsid control measures with gamma-BHC will be carried out in the area, it is now unnecessary for dieldrin to be applied to the canopy.

MARMARA STUDIES

An experiment has been started to investigate the seasonal incidence of Marmara sp. in which pod, fan and chupon tissue are being sampled.

All plots involved will receive routine gamma-BHC applications against capsids whilst half will also be treated with dieldrin (as applied in ant control work) so that it should be possible to gather precise information about the effects of this persistent insecticide upon population densities of Marmara.

At the beginning of the experiment fresh Marmara damage was almost entirely absent though some old damage, free from larvae, was still evident.

The first dieldrin application is due at the end of July, 1958.

MINOR PESTS OF CACAO

Scolytidae

Following identifications made by the Commonwealth Institute of Entomology, shot-hole borer damage to seedling cacao in Sierra Leone (first mentioned in Quarterly Progress Report No.49) has been found to be principally associated with Xyleborus morstatti Hag.

Of the 99 adult insects, received either in spirit-collections or removed from samples of damaged chupon tissue, 90 proved to be X. morstatti, 4 Hypothenemus mozambiquensis Egg., 4 Hypothenemus sp. ? pusillus Egg. and one unidentified species.

Similar damage noted by workers in the Ivory Coast was also attributed to X. morstatti. This species has also been recorded attacking seedling cacao in Ghana and Nigeria.

Lepidoptera

The following identifications of adult Lepidoptera, bred from larvae found attacking cacao at Tafo, have been received from the Commonwealth Institute of Entomology:-

ARCTIIDAE	Diacrisia rattrayi Rths.
	D. aurantiaca Holl.
NOCTUIDAE	Prodentia litura F.
	Earias biplaga Wlk.
	Lophocrama phoenocochlora Hmps.
	Characoma stictograpta Hmps.
	Anomis leona Schaus.
LYMANTRIIDAE	Stracena fuscivena Swinh.
	Orgyia basalis Walk.
	Euproctis sp.
NOTODONTIDAE	Scalmicauda sp.
GEOMETRIDAE	Neocleora sp.
PYRALIDAE	Polygrammodes hirtusalis Walk.
LASIOCAMPIDAE	Liepoxais sp. nr. peraffinis Holl.
LIMACODIDAE	Semyrilla lineata Holl.
	Parasa viridissima Holl.

TORTRICIDAE Enarmonia (Laspeyresia) sp.
XYLORICTIDAE Odites sp.

The most common of these at Tafo are D. rattrayi, P. litura, E. biplaga, C. stictograpta and A. leona all of which are known to be widespread on cacao in West Africa and also to have polyphagous habits.

During the past thirty years 75 species of Lepidoptera have been recorded attacking cacao in West Africa and about half this number in Ghana alone: undoubtedly the list is still largely incomplete.

POLLINATION STUDIES

The effects of insecticides on pollination, setting and insect numbers

This experiment has now been terminated and the results will be written up.

AGRONOMY DIVISION

Routine fertilizer application

Following the first-year results of the Shade and Manurial Trial, fertilizers are being applied on a routine basis to about 67 acres of the Institute's experimental cacao. Rates of application are:

April-May N - 35 lb.N/acre as urea
P - 70 lb.P_2O_5/acre as triple superphosphate
K - 50 lb.K_2O/acre as potassium sulphate
Mg - 35 lb.MgO/acre as magnesium sulphate

September N - 35 lb.N/acre as urea.

A comparison of the routine fertilizer mixture and a proprietary brand "Nitrophoska yellow" has been super-imposed on the Amelonado Source Trial.

Amelonado Pruning Trial

Half of each of the pruned and unpruned plots in the Amelonado Pruning Trial have received a routine fertilizer dressing. This trial is now intended therefore to determine whether the initial higher yields are maintained on the pruned cacao, and to determine the effect of fertilizer on the yield.

Cover crops and mulches

A small experiment, covering one acre, has been started to determine the effect on soil moisture, organic matter and soil structure of certain cover crops and mulches. The following

treatments are being applied:

A. Guatamala grass
B. Guatamala grass mulch
C. Tradescantia sp.
D. Crotallaria striata
E. Stylosanthes gracilis
F. Bare soil
G. Natural regeneration
H. Inert mulch.

Cacao will be established on these plots after one year's soil observations.

CHEMISTRY DIVISION

SOIL FERTILITY

The new experiments noted in the previous Quarterly Report have all been laid down. In addition, a small-scale pot experiment has been started to study the effect of varied light intensity on cacao seedlings, with and without fertilizer. Amazon cacao type T73 is being grown from seed in a WACRI soil at five levels of light intensity, viz. 100, 75, 50, 25 and 15 per cent sunlight approximately. The various shade conditions are obtained using aluminium strips, and the percentage quoted refers to the proportion of open area between the strips. An NPKMg fertilizer mixture is applied to half of the seedlings, the remainder being untreated. The pots are sited in concrete tanks filled with water to a depth sufficient to maintain an adequate continuous supply of moisture to the seedlings.

COCOA PREPARATION AND QUALITY

Methods of fermenting and drying small quantities of beans, from a few ounces up to about 25 lb., are being investigated. Recent work at WACRI and elsewhere suggests that a rapid temperature rise to an optimum temperature range and the maintenance of the temperature within this range for a short period may be all that is required for satisfactory fermentation. Work along these lines has been started.

Previous work has shown that in good quality Amelonado cocoa the amount of anthocyanins in the finished bean is less than 10 per cent of that originally present. Because of its bearing on the processing of cocoa, the influence of temperature and humidity on the rate of destruction of anthocyanins in beans killed by different treatments is being studied.

I B A D A N S U B - S T A T I O N

PATHOLOGY SECTION

VIRUS RESEARCH

A paper with the title "Virus diseases of cacao: the World situation" has been prepared (by J.M. Thresh & T.W. Tinsley) and will be presented by Mr. Lamb at the forthcoming Inter-American Cocoa Research Conference in Colombia. In the paper, it is pointed out that virus diseases of cacao have been found in Ghana, Ivory Coast, Nigeria, Trinidad and Ceylon and may also occur in Venezuela, Colombia, Java and Sumatra. The available information on the viruses isolated from diseased cacao is summarised and it is provisionally suggested that three distinct viruses occur in West Africa. These are referred to as cacao necrosis, cacao mottle leaf and cacao swollen shoot viruses and their main features are summarised in the following sections.

Cacao Necrosis Virus

Acute necrotic stage of infection followed by recovery phase with limited leaf symptoms, but no swellings.

No red vein banding or mottle on flush leaves.

Translucent distorted patches on hardened leaves, but no reticulate mosaic.

Not transmitted by mealybugs although outbreaks spread slowly.

Unrelated to other cacao viruses by protection tests.

Apparently restricted to adjacent localities in south-west Nigeria.

Isolates show minor variation in symptoms and effects on growth.

Cacao Mottle Leaf Virus

No marked distinction into acute and chronic phases of infection and no necrosis or swellings.

Extensive red vein banding and mottle on flush leaves.

Reticulate mosaic symptoms on hardened leaves caused by clearing and banding of the veinlets between the main veins but not alongside them.

Transmitted by several mealybug species excluding Ferrisiana virgata (Ckll.).

Host range apparently restricted to Tiliales.

Unrelated to other cacao viruses by protection tests.

Apparently restricted to baobabs, Adansonia digitata L., north and south of the main cacao areas and to scattered outbreaks in the cacao of Trans-Volta and Togoland.

Minor variation between different isolates from baobabs and cacao.

Cacao Swollen Shoot Virus

Usually a distinction into an acute stage of infection without necrosis and a relatively mild chronic phase, with swellings.

Red vein banding on flush leaves but not causing a general mottle.

Reticulate mosaic symptoms on at least some hardened leaves caused by clearing and banding of the veinlets between and alongside the main veins.

Transmitted by several mealybug species usually including F.virgata.

Host range apparently restricted to the Tiliales and Malvales.

Unrelated to other cacao viruses by protection tests, which indicate different degrees of relationships within the complex.

Widespread in most of the important cacao areas of Ivory Coast, Ghana and Nigeria.

Minor variation between isolates from the same trees and localities, with greater variation between isolates from different areas.

Not found in baobab but occur in other indigenous hosts from which they may have been derived.

The cacao mottle leaf and cacao necrosis viruses are apparently of limited importance as they have a restricted distribution, but the various forms of swollen shoot virus are widespread and there is considerable variation between the symptoms caused by the numerous isolates which are ascribed to this complex. Differences have also been noted between the range of hosts infected by the eight isolates which have been studied in detail. Moreover, the different isolates are not uniformly transmitted by all the mealybug species which are vectors, while the limited number of protection tests which have been carried out indicate that certain isolates are closely related, although most of them are not.

These observations do not provide a reliable basis for subdividing the swollen shoot complex. Nevertheless the protection tests suggest that certain isolates may be regarded as strains, some of which are closely related and form immunologically distinct groups. Thus the New Juaben isolates and the ones from Kononge, Kongodia and Dawa form one group and the various isolates from the Koroboto outbreak in Nigeria form a second. Similarly the isolates from Olanla and Ilesha form a third group and further work is likely to reveal others, as the occurrence of numerous symptom variants which protect against each other appears to be a general feature, at least of large outbreaks. The variation between isolates from different parts of the same outbreak and within each virus group appears to be continuous and of a different order from the discontinuous variation between isolates from different outbreaks and virus groups. The origin and occurrence of these variations is at present under investigation and may be due to the spread of virus into cacao from different wild hosts.

In preliminary work, some of the more important Nigerian isolates have been transmitted by single insects in an effort to establish stable cultures. In this way particularly mild forms have been obtained which are virtually latent and give only transient red vein banding symptoms and a chlorotic vein banding which is barely discernable with a hand lens. Detailed work is also in progress on the value of protection tests as criteria of relationship and attempts are being made to work out a technique which is more likely to detect interference between isolates than the one in use at present involving grafting methods.

INSECT TRANSMISSION OF CACAO VIRUSES

Cacao necrosis virus

When experiments on the insect transmission of cacao necrosis virus were started, groups of seedlings were inoculated at weekly intervals as source plants. Inoculations were done by patch grafting, and though most seedlings were cut back at once, a few were left intact. Only 20 per cent of the grafted seedlings developed necrotic symptoms on the first or second flush, the others remained symptomless. This prompted an investigation of the factors governing the expression of symptoms and the following variations have now been observed:

(a) Symptoms occur first on the leaves of the first flush when they are 1 to 2 inches long and spread to the leaves of the second flush at an early stage. The dead leaves of the first flush remain firmly attached to the plant, as with potato virus Y (leaf drop streak). Symptoms usually appear during the third week after inoculation, but later at the height of the rainy season.

(b) Necrosis affects first the leaves of the second flush, when they are still less than 0.3 inch. long. These leaves fall off easily. Symptoms occur four weeks after inoculation but there may be some delay during the wet season.

(c) Inoculated plants remain symptomless, unless they are cut back once or twice. Surviving seedlings will then develop symptoms of type a or b.

Inoculations of cacao necrosis virus from the outbreaks at Omi-Aboderin have given symptoms of all three types, type c being by far the commonest. Symptoms of types a and c or types b and c were obtained from the same tree. Three isolates of cacao necrosis virus, which each have given the same symptoms as described under a, b and c several times in succession, are being maintained in the greenhouse. The results of some experiments with these isolates will be reported later.

The possibility that Cola spp., which commonly occur in the area where cacao necrosis virus is found, are wild hosts of this virus is being investigated. Preliminary experiments have shown that grafts from Cola spp. to cacao seedlings and vice versa are possible. The results of an experiment with Amelonado seedlings were inconclusive, while in a second experiment with Amazon seedlings very similar symptoms were observed on seedlings grafted with patches from Cola spp. and seedlings inoculated with cacao necrosis virus. More work is required, however, to establish the susceptibility of this species to cacao necrosis virus.

Experiments on insect transmission of cacao necrosis virus have now included the aphids Toxoptera aurantii B.d.F., and T. citricidus Kirkaldy, the psyllid Tyora tessmanni Aulm., the mealybugs Ferrisiana virgata (Ckll.) Pseudococcus njalensis Laing and Planococcus citri (Risso), and some unidentified leaf-hoppers from the outbreak at Omi-Aboderin, but no transmissions have been obtained.

Cacao mottle leaf and swollen shoot viruses

In transmission tests with single insects and source plants infected simultaneously with the isolates from Alaparun and Elepo, Ferrisiana virgata (Ckll.) has transmitted the Alaparun isolate, together with the one from Elepo. In previous work (Posnette, Ann.appl.Biol., 37, 378, 1950 and other workers) F.virgata did not transmit the Alaparun isolate from source plants infected with this isolate only. The work on the availability of virus in plants and selective transmission has been discontinued, and the experiments on virus complexes in infected plants are being extended.

It is known that the symptoms of infected plants vary in severity with the number of insects and the insect species used. A possible explanation for this may be that there are complexes in infected plants which are transmitted by several insects while single insects transmit only one of the components. A source plant infected with an isolate from Elepo, which had been transmitted by single insects three times in succession has been used in an experiment to compare the infections caused by single and groups of five insects, but the symptoms varied as usual. Similar experiments with other Nigerian isolates are still in progress.

STUDIES ON "DIE-BACK" OF CACAO

The observations on the increase of existing areas of "die-back" on mature trees treated with insecticides and on untreated control trees have stopped because the Western Region Ministry of Agriculture has suspended the capsid spraying programme on these plots. The data already obtained will be analysed and the results reported later.

In an investigation of the importance of capsid lesions in initiating "die-back", observations, made over a period of six months, showed that of the one hundred marked twigs, twenty-eight had died back below the initial scoring mark, twenty-two had some "die-back" and fifty were healthy. From one to fifteen infected capsid lesions were recorded on twigs that had died and also on twigs that had remained healthy and it is suggested that there is no direct relationship between the number of capsid lesions occurring in woody tissue and subsequent "die-back".

The majority of the 90 trees coppiced in June, 1957 produced chupon growth and the inoculation of the coppiced stumps with C.rigidiuscula had no apparent effect on

regeneration. A further ninety trees were coppiced and inoculated in December, 1957. Regeneration of these trees was better than in the previous experiment, but again the fungus had no apparent effect on regeneration.

The experiment to determine the effect of fungicidal sprays and pruning have continued. Each month, new "die-back" areas were found as frequently on the treated as on the untreated trees. An analysis of fungi occurring in these new areas showed that there was less C.rigidiuscula in the sprayed plots than in the non-sprayed ones.

Irrigation treatments have continued during the rains and the rate of increase of existing dead areas of wood on these trees is apparently unaffected. The slight, beneficial effect of irrigation on the decreased incidence of new areas of "die-back", reported last quarter, has not been maintained.

The effects of a varying water supply, the presence and absence of shade, two degrees of defoliation, two levels of nitrogen, two of phosphate and two of potassium and two levels of an NPK mixture are being studied in relation to the spread of lesions made by a sterile needle and also by a needle contaminated with spores of F.decemcellulare, in the stems of 12 to 16-month-old Amelonado seedlings. In mature trees the effects of the presence and absence of shade, root pruning, defoliation, ring barking and fertilizers on the spread of sterile and F.decemcellulare contaminated lesions are being studied.

Examinations made after four and twelve weeks showed that a) both excess and inadequate watering increased the spread of F.decemcellulare contaminated lesions but not that of sterile ones.

b) defoliation had at first no effect on lesion spread but subsequently full defoliation resulted in a rapid increase of the F.decemcellulare contaminated lesions,

c) the presence or absence of shade had noteffect on the lesion spread.

WEST AFRICAN FUNGICIDE RESEARCH UNIT

The West African Fungicide Research Unit has been seconded to the Sub-station from the Colonial Pesticides Research Unit, Tanganyika, to investigate the chemical control of black-pod disease of cacao. The Unit at present consists of a Chemist and a Plant Pathologist.

For a number of reasons the Unit will confine itself to laboratory work and small scale field experiments, for this season

at least. An attempt will be made to evaluate the efficiency of a number of fungicides in terms of their fungi-toxicity, weathering properties and residual fungicidal effect, along the following lines:

a) Examination of a suitable technique for the inoculation of pods with P.palmivora.
b) Examination of the effectiveness of a number of fungicides applied to pods prior to inoculation.
c) Examination of the weathering properties of a number of fungicides applied at different rates and of varying droplet size under natural and artificial conditions.
d) Examination of the efficiency of the various deposits after weathering in preventing infection by P.palmivora.

It is felt that a biological assessment of various levels and forms of fungicide deposits, determined chemically, is essential for cross reference purposes. Several methods for doing this have been investigated and the method of taking sample-washings has been rejected because of the difficulty of removing all, or known quantities of fungicide from definite areas of the pod surface. Methods of inoculating unwounded pods to cause multiple infection using a technique which will cause a minimum of fungicide deposit redistribution are being investigated.

During the course of this work the liberation of zoospores from sporangia has been examined and the optimum conditions for this are being investigated. Germination of sporangia in hanging drops of water is not necessarily mainly by germ tubes as previously reported (see Rep.W.Afr.Cocoa Res. Inst., 1948-49, p.50). Sporangia have germinated indirectly in hanging drops at 80°F, confirming that 71°F is not a critical temperature for zoospore liberation (cf. Quarterly Report No.46).

J.T. Martin (Rep.agric.hort.Res.Sta.Bristol., 1956, p.125) has developed a simple method for determining copper fungicide residues on foliage. The modifications for its use to measure residues on cacao pods are being worked out. The variation in deposits both over the surface of a given pod and on pods in different parts of the cacao trees after routine spraying is being studied.

AGRONOMY SECTION

Agodi Cacao Experimental Farm

The farm was taken over from the Western Region Department of Agriculture in April. It comprises blocks of randomly planted cacao, totalling 9.75 acres, on which individual tree records have been kept since 1943. Routine maintenance has been carried out, and it is planned to thin the rather dense shade, using arboricides.

A manurial trial with an 'N-P' and 'K-Mg' 2^2 factorial design, replicated six times, has been started. The fertilizers are broadcast over the plots at the following rates:

N - 100 lb. N/acre/annum (as urea)
P - 100 lb. P_2O_5/acre/annum (as triple superphosphate)
K - 50 lb. K_2O/acre/annum (as potassium chloride)
Mg - 50 lb. MgO/acre/annum (as magnesium sulphate).

The first applications were made in May. The general layout of this experiment is similar to that used in Ghana (cf. Quarterly Report No. 45, p.22). It is hoped to obtain sites in other parts of the region later in the year, for similar trials.

SOA.